UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
P. O. BOX 1198
ADA, OKLAHOMA 74820

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May 28, 1992

MEMORANDUM

SUBJECT: Monsanto - J.F. Queeny Plant, St. Louis, Missouri
RCRA Facility Investigation Report, Dated March 1992
(92RC07-002)

FROM: Steven D. Acree, Hydrologist
Applications and Assistance Branch

TO: Randy Rohrman, Hydrogeologist
RCRA Branch
Waste Management Division
U.S. EPA, Region 7

Per your request dated April 22, 1992, the ground-water flow and contaminant transport modeling efforts reported in the referenced document have been reviewed by members of the Technology Support Center, under my direction. Reviewers were Drs. Jeffrey Johnson and Varadhan Ravi, Dynamac Corporation and me. The comments provided below represent a compilation of the concerns and recommendations expressed by members of the review team. In general, the overall modeling effort appears to be unsound from a scientific viewpoint. There are numerous aspects that need further clarification. The apparent lack of data required to support assumptions used in the models is of particular concern. These concerns and recommendations for making the modeling study more rigorous are discussed in detail below.

Ground-water Flow Modeling

1. The choice of the numerical code, MODFLOW, is appropriate and the model discretization appears to be reasonable. However, the treatment of boundary conditions is inadequate. Modeling the Mississippi River as a constant head boundary does not appear to be appropriate as the river stage can fluctuate significantly. This would invalidate the assumption of a steady flow field. It may be revealing to study the relationship between river stage and ground-water elevation using a lumped parameter systems (or a transfer functions) approach. The designation of north, south, and west boundaries as no-flow boundaries appears to be arbitrary and without sufficient justification. Adequate data (e.g., locations of hydraulic or topographic divides, sufficient piezometric data to estimate flow lines at the proposed boundaries, etc.) were not presented to support the choice of boundary conditions. Further, Figure F2-5 shows velocity vectors

that appear to be normal to the west boundary in apparent violation of the no-flow boundary condition. This point requires clarification.

2. The degree of hydraulic communication between the bedrock and the alluvium does not appear to be well defined. The data supporting the conclusion of very limited communication are sparse and somewhat contradictory (e.g., apparent response of ground-water elevations in bedrock to ground-water extraction during the aquifer test, notation of potential vertical flow components between the alluvium and bedrock). It is not clear how this affects the 2-D conceptualization of ground-water flow at this site. This issue was not considered in this study and adequate justification for neglecting this potential flow component was not provided. In addition, the potential for karst features in the limestone in the vicinity of the site was not discussed. It is recommended that regional, local, and site-specific studies be consulted to allow evaluation of this potential.

3. It is not clear that the hydraulic conductivity distribution used in the model is supported by the data presented in the report. The reported information from slug tests and the constant discharge aquifer test was not sufficient to characterize the site to the degree implied by the zonation used in the model. In addition, some of the estimates of hydraulic conductivities from slug tests appear to be significantly different from values assigned to the respective zones. It is recommended that the spatial distribution of hydraulic conductivities estimated from slug tests and the constant discharge aquifer test be displayed on Figure F2-2 and the rationale for the zonation be thoroughly discussed with regard to the available data.

A brief review of the data obtained from the constant discharge aquifer test indicates that hydraulic conductivity estimates calculated using data from the more distant observation wells may be suspect. It appears that ground-water elevations in these wells were affected by local influences other than extraction from well TW-1 (e.g., changes in river stage or, possibly, influence from local industrial production wells). It did not appear that sufficient data were available to correct for these effects.

4. The flow model was calibrated using ground-water elevations observed in June 1991. Although these values are tabulated in Table F2-2, the inclusion of a potentiometric map would be useful in review of this information. It appears that the ground-water elevations fluctuate significantly through time. This fluctuation is probably due, in part, to fluctuations in river

stage. These fluctuations and changes in potential ground-water flow directions are not well defined. It may be insightful to calibrate the flow model using data from measurements obtained in October 1991 and compare the parameter values with those obtained using the June data.

5. The model appears to assume homogeneous recharge of 10 inches/year. This appears to be a dubious assumption as the available information indicates much of this area may be covered by impervious surfaces. In addition, no supporting data were provided for the choice of the recharge value. Justification for the choice of this parameter and the assumption of uniform recharge should be provided.

6. The assumption of constant porosity is questionable. The problem domain is comprised of different materials with different hydraulic properties. The justification for this assumption should be discussed.

Contaminant Transport Modeling

7. The conceptual model for this site does not appear to adequately reflect current conditions. Immiscible liquids have been observed in the subsurface. It appeared that liquids with densities greater than water (DNAPLs) and liquids with densities less than water (LNAPLs) had been observed. In addition, elevated constituent concentrations in soils and ground-water provide indirect evidence for the existence of immiscible phase contaminants. It did not appear that the composition, properties, and distribution of these liquids had been adequately defined. These liquids may exist as mobile free-phase liquids (e.g., those observed in monitoring wells) or as residual saturation trapped in soil pores. Both free-phase liquids and residual saturations of these liquids provide long term sources for continued ground-water contamination, particularly when present below the water table. This vital concept appears to have been neglected in development of the conceptual model for contaminant transport and fate.

Based on the previous discussion, it does not appear that source considerations were adequately addressed in view of the available data. Two scenarios were modeled in this study. Scenario 1 assumed lack of continuing contaminant source. This scenario appears to be unrealistic based on the available information. Immiscible liquids in the subsurface would provide a continuous source for ground-water contamination. Scenario 2 appears to involve a source conceptualized as recharge through contaminated soil. This conceptualization also appears to neglect immiscible liquids in the saturated zone as a major potential source. As noted above, the available data are not sufficient to define the nature and distribution of subsurface contamination at the site, particularly the distribution of immiscible liquids.

8. Contamination at the site was represented in the model by total concentrations of volatile organic constituents with the assumed properties of chlorobenzene based on the elevated concentrations of this constituent detected in soil and ground water. It is noted that additional constituents and immiscible liquids have been detected, including the observation of immiscible-phase tetrachloroethene in previous studies. The distribution of these contaminants is not well defined. It should be noted that the actual flux of specific contaminants to the Mississippi River may be quite different from that indicated by such a generalized transport model depending on the distribution, composition, and properties of these immiscible liquids, dissolved constituents, and subsurface materials.

9. The model assumed contaminant decay using a single literature value for half-life of chlorobenzene. This approach may be inappropriate. The cited reference of Howard et al. (1991) indicates that the first-order decay constants for most chemicals are not directly measured, but are based on scientific judgement. Contaminant decay rates will be site specific and difficult to determine. Therefore, a sensitivity analysis should be performed with an appropriate range of decay constants to assess the impact of this important parameter. The most conservative assumption would be based on "no decay" transport simulation. This situation should also be analyzed.

In addition, it appears that the assumed decay constant was applied to the source term in Scenario 2. Such an assumption may not be appropriate at this site. Decay rates for immiscible contaminants present in a pool or lens in the saturated zone may be quite different from rates applicable to dissolved constituents.

10. Neither calibration of the transport model nor sensitivity analyses were performed. Performance of these tasks would add to the credibility of this study. The report points to the lack of sufficient chemical concentration data as the reason for not calibrating the transport model. However, the report states that the source strength for the "constant source scenario" was estimated such that the observed dissolved constituent concentrations were replicated by the model. It is noted that this task is a component of model calibration. The results of this task should be more thoroughly discussed including a comparison of the modeled and observed aqueous constituent concentrations.

11. The boundary conditions for the transport model were not explicitly stated, particularly the boundary condition applied at the river. These conditions should be explicitly stated and thoroughly discussed.

12. The modeling effort, as presented, lacks rigor in several aspects. As previously noted, many of the assumptions and claims are either unsupported or in conflict with field observations. Therefore, it is recommended that the following tasks be performed in order to provide a more rigorous basis for the study.

a) Refine the conceptual model for contaminant transport and fate at this site as previously discussed.
b) Provide supporting data for locations of no-flow boundary conditions used in the model.
c) Investigate the effects of changing river stage and modeling of the flow as a transient phenomenon.
d) Perform model calibrations using June and October 1991 ground-water elevation data.
e) Present the spatial distribution of hydraulic conductivities estimated from aquifer testing (constant discharge and slug tests) on a map and compare this with the calibrated zonal values. Provide better justification for the choice of zonal values.
f) Use appropriate values of porosity for the different subsurface materials.
g) Conduct sensitivity analysis on the chemical decay parameter and other pertinent parameters.
h) Calibrate the transport model.
i) Clearly define and justify the boundary conditions for the transport simulation.

If you have any questions concerning these comments and recommendations, please do not hesitate to contact me (700-743-2322) at your convenience. I have enclosed a copy of a recent publication entitled Dense Nonaqueous Phase Liquids - A Workshop Summary for your information. We look forward to future interactions with you concerning this and other sites.

Attachment

cc: Hugh Davis, OS-341
Bill Pendicino, Region 7
Mark Collins, Region 7
Dick Scalf, RSKERL
Dr. Jeffrey Johnson, Dynamac
Dr. Varadhan Ravi, Dynamac